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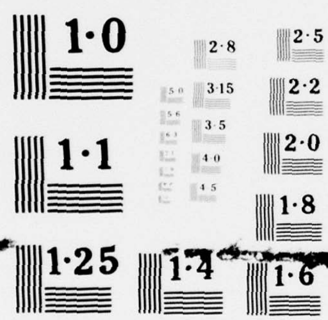

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ASSESSING INSTRUMENT SENSITIVITY FOR HEADING AND ATTITUDE INFORMATION

By

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August 1977

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The three studies, described in this report, concerned the assessment of procedures which influence instrument sensitivity in military flight instruction. The ability to determine the relative location of an in-flight vehicle from a set of dial indicators was influenced more by students' expectations than by context. Sensitivity to heading and attitude information was increased when learners were supplied with overt attention control. The teaching of instrument sensitivity appears best facilitated by employing publically observable responses during training, and seems to be a function of the degree to which the learner can be directed to use a spacial processing mechanism during initial encoding.

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ASSESSING INSTRUMENT SENSITIVITY FOR HEADING AND ATTITUDE INFORMATION

Introduction

Assuring that students will achieve adequate levels of instrument sensitivity is an important goal of flight instruction. When an experienced pilot scans his cockpit instruments, he automatically encodes the readings and translates them into aircraft status configurations. It is this constant parade of different spacial sets which provides the feedback necessary to guide the airplane within the flight plan limits. In fact, an important way in which student pilots differ from their more experienced counterparts is in their ability to turn instrument readings into accurate representations of aircraft position.

The studies, described in this report, are concerned with investigating ways in which naive learners approach the task of instrument interpretation. Assessment of procedures, which influence the translation of attitude and heading data into aircraft position statements are of interest. Initially, it is a difficult task for the students to produce concrete, pictorial referents based only on information supplied by attitude and heading indicators. Trial data show clearly that the integration of flight direction and banking movements is accompanied only very slowly by the ability to visualize the actual aircraft position. The first study is concerned with ways in which the interpretation process might be developed more rapidly, and with the specific effects of overtly generating positional information from both aircraft and instrument representations. Producing instrument readings from pictured aircraft may act to direct attending behavior in the same fashion that information modeling reduces training time in more complex tasks (Smith & Smith, 1968). On the other hand, if overt attention is directed primarily to the aircraft, there may be an increase in error responses, simply because there is less actual practice time devoted to the instrument configuration. Under this latter condition, the overt-plane group may exhibit essentially the same performance level as the control group.

Experiment I

Design and Subjects

One factor, task requirement, was varied across three levels of interaction with the instrument-aircraft materials. The overt-plane group was asked to draw a visual representation of aircraft position based on a set of readings from the heading and attitude indicators. Subjects in the overt-indicator condition were told to enter appropriate readings on the heading and attitude dials based on the position of the aircraft displayed on the page above. Finally, the control group simply studied the relation between the pictured aircraft and the indicators.

The subjects were 30 undergraduates attending courses in educational psychology at Arizona State University. Subjects were randomly assigned, 10 to each between-subjects group, in order of their appearance

for the experiment.

Materials

The stimulus materials used in the experiment consisted of 36 recognition items, each composed of two dial indicators and four drawings of a standard, single-wing aircraft in various flight positions. These materials represented a modified version of the types of items used to measure flight training potential (Reid, 1976). In their initial form, each item filled an entire 5½-by 8½-inch page, with the four pictures of aircraft at the top, each with a letter designation A through D, and the two dial indicators directly below at the bottom of the page. The original items were produced such that one of the aircraft positions on each page corresponded to both the heading and attitude readings shown on the indicators below. For the present experiment, the 36 items was randomly divided into two groups of 18 items each. One such group was designated the training items and was used during the manipulative portion of the study. The second 18-item set was identifed as the test items, and were used as the dependent measure for all conditions. Following the experimental treatment, each subject received the 18 test items and responded to each question by selecting which aircraft drawing accurately represented the readings shown on the two indicators.

Subjects in the overt-plane condition received 18 training items in which only the dial readings were available. Subjects read the dials and then attempted to draw an aircraft in the space above which corresponded to the heading and attitude information given. For this group, preliminary instructions stressed that artistic ability was unimportant, and that no judgment would be made concerning the quality of the picture drawn. In the overt-indicator treatment, the learners saw a drawing of an aircraft in the upper-page panel, and were told to correctly enter the appropriate indicator positions in the two blank dials below. Finally, subjects in the control group received both the four aircraft choices, and the set of dial readings, and were asked to study the material carefully. The control group also received feedback regarding which of the drawings was the best representation of the readings provided.

Prior to the experimental task, all learners received a sheet of instructions concerning the use of heading and attitude information, and how such data related to the pictured aircraft. The preliminary instruction took about five minutes for completion.

Responses to the 18-item posttest were recorded on standard machine processed answer sheets. All subjects were instructed to guess if they did not know an answer.

Procedure

Subjects were tested in groups ranging from eight to twelve persons, with subjects from all three groups participating in each session. When all of the subjects in a given group were seated in the testing room,

each of them was given both a training and test booklet numbered one and two-respectively. Next, subjects were asked to place book two on the floor beside them and to read the instructional material contained in the first pages of book one. When everyone had finished studying the preliminary material, the experimenter answered general procedural questions, and subjects began to work through the training booklets. No time limit was placed on completion of the training materials, and each subject was required to record his training completion time to the nearest 15 sec. from a time board visible at the front of the room. When a learner completed the 18 training items, he raised his hand, recorded his time, and an experimenter removed his training materials and replaced them with booklet two from the floor beside the subject's chair. Subjects then worked through the 18 test items at their own speed, handed in the second booklet, and left the room.

RESULTS

The protocols for each subject were scored for number correct on the 18-item posttest, and for total completion time during training. Table 1 presents the means and standard deviations for each of these measures across the three treatment conditions. An overall analysis of variance on posttest corrects did not reach significance ($F = 2.73$), but contrasts performed on the groups' means showed that the overt-indicator group recognized significantly more correct aircraft positions than the overt-plane condition ($\underline{p} < .05$). An analysis of variance on the training time data yielded a significant result for the amount of time spent working on the training items, $\underline{F}(2,27) = 7.64$, $\underline{p} < .01$. Post hoc Newman-Keuls tests among the time means showed only that the overt-plane group took significantly more time to study the material than did the overt-indicator condition ($p < .05$). No other comparisons were significant. In order to further evaluate the relationship between time and recognition, Pearson correlation coefficients were calculated between number correct and minutes to completion for each of the three experimental groups. For each group, the correlations were: overt-plane = +.59, overt-indicator = +.25, control = +.12. With the relatively small $\underline{n}$ in each group, only the overt-plane coefficient was significantly different from zero ($p < .05$).

Table 1

Means and Standard Deviations for Posttest Corrects and Training Completion Time: Experiment I

Variable		Task Requirement: Overt Plane	Overt Indicator	Control
Posttest Corrects	M	11.60	14.90	13.20
	SD	3.13	2.42	3.76
Completion Time (minutes)	M	22.56	11.59	12.37
	SD	11.44	2.75	2.92

DISCUSSION

In line with the original predictions, the overt-plane condition yielded significantly lower performance than the group who concentrated on the dial completion task. In spite of the fact that overt-plane times on the training task were significantly longer, there was no consequent facilitation due to the act of constructing the aircraft from the readings. The correlation between training time and recognition performance does suggest that learners who worked longer at the construction task were more likely to obtain higher scores; however, the increases in time for these subjects was not a sufficient condition for better judgment performance on the posttest. One possible reason for these results may lie in the overt drawing activity itself. It may be that the act of producing the drawing prevents subjects from emphasizing the spacial locating components of the dial-aircraft relation, hence reducing the learner's later ability to "match" the readings with the drawings on the posttest. One would not expect the same sequence of events with the overt-indicator condition, since these subjects spend much of their time assessing the spacial characteristics of the aircraft in order to be able to produce the appropriate readings. In order to test such a possibility, Experiment II was designed to include specific instructions for subjects to pay attention to the imaginal component of the production task. Also, since well-formed images, like their semantic counterparts, may have their greatest benefit over time, we included a delay test in the second study. Essentially, the predictions state that overt-plane learners should demonstrate higher recognition ability under instructions to pay close attention to spacial elements of the aircraft. Finally, because of the retention component involved in the delay test, the overt-plane subjects should show even higher correct performance over a time interval, simply because the image manipulation should

have its greatest effect over time (c.f. Paivio, 1971).

Experiment II

Design and Subjects

Two factors, task requirements and test occasion, were varied to form three factorial cells. The levels of task requirement were identical to those used in Experiment I, and the test occasion variable was defined by both an immediate and delayed presentation of the same 18-item posttest used in the previous study. The design was thus a three-task requirement (overt-plane x overt-indicator x control) by two-test occasion (immediate x delay) factorial with repeated measures on the test occasion variable. Across the task requirement cells, the only difference between this study and Experiment I was that all subjects received explicit instructions to attempt to form vivid mental images of each heading-aircraft solution encountered during training.

The subjects were 27 different undergraduates from the same population described in Experiment I. Subjects were randomly assigned, nine to each between-subjects cell, in order of their appearance for the study.

Materials

The materials were identical to those used in the earlier study, with the exception that a third booklet was constructed consisting of the same 18 items used on the posttest. The third booket was administered as the delay measure only to subjects in the overt-plane and overt-indicator conditions. The control group did not receive the delay posttest simply because they did nothing more than practice the response selection over the two previous presentations.

Procedure

Subjects again participated in groups, with learners from all conditions present at each session. The procedure was identical to that of the first experiment, except for the image instructions and the administration of the delay test to the overt groups. Instructions to form images of the training activities were presented prior to beginning work on the training booklet. Subjects were told to form vivid pictures as they read, and emphasis was placed on the fact that forming images would facilitate recall of the material. When subjects had completed both training and immediate test, the control group was allowed to leave, and the learners in the overt conditions were asked to "take a break" for ten minutes before the final task. At the end of the interpolated interval, the subjects in the overt groups received the third booklet containing the second posttest, and were asked to complete it in the same fashion as with the previous items. No time limit was placed on completion of the delay measure.

RESULTS

All subject protocols were again scored for both correct test responses and training completion times. The first analysis was a 2 (overt task requirement) by 2 (test occasion) analysis of variance on number of correct test responses. This analysis yielded a significant main effect for test occasion, $F(1,16) = 6.61$, $p < .05$, and a marginal effect for the task requirement x test occasion interactions, $F(1,16) = 3.07$, $p < .10$. The means contributing to the interaction are shown graphically in Figure 1. Next done was an analysis of variance on training completion times. The main effect for the second analysis was significant, $F(1,24) = 8.43$, $p < .01$, and Newman-Keuls tests among the means showed the rank order: overt-plane > overt-indicator = control ($p < .05$). The time means and standard deviations are displayed in Table 2. Finally, a Dunnett's test was used to compare the overt task groups with the control for the posttest corrects measure. This comparison did not reach statistical significance.

DISCUSSION

The results of this second study support the initial predictions concerning visual-spacial processing. Although it is only marginally significant, the interaction between overt-task and test occasion buttresses the argument that when production of the aircraft stimuli is accompanied by image construction on the part of the subject, there is an increase in performance for a delay measure. It appears that instructions to image have essentially the same effect with spacial relations as they do with concrete verbal representations. In the present case, the significantly longer training times yield an increase in retention under conditions where the learner attempts to visualize the test solutions during training. The reasoning is, of course, that the act of generating images allows the subject to focus more primary attention to the locational elements, thereby increasing any benefit derived from an overt identification of the aircraft positional information. Obviously, one could argue that any type of attentional device would facilitate in the same fashion (e.g., Anderson, 1970). If this were the case, then our recommendations for increasing instrument sensitivity would be somewhat different, and much less oriented toward a spacial processing point of view. Consequently, in order to test whether or not the locus of effect is in the image manipulation per se, the third study was designed in an attempt to determine if correct performance on the overt-plane task can also be influenced by a manipulation involving a motivational rather than a spacial element. In this study we either did or did not provide subjects with a preinstructional statement aimed at increasing test performance. If the drawing procedure was increased primarily by the spacial component of the image instructions, then we would expect to find no differences between the overt task groups. Alternately, if the locus of effect is simply to increase attention to the task, we would hope to produce higher performance for the prompted condition.

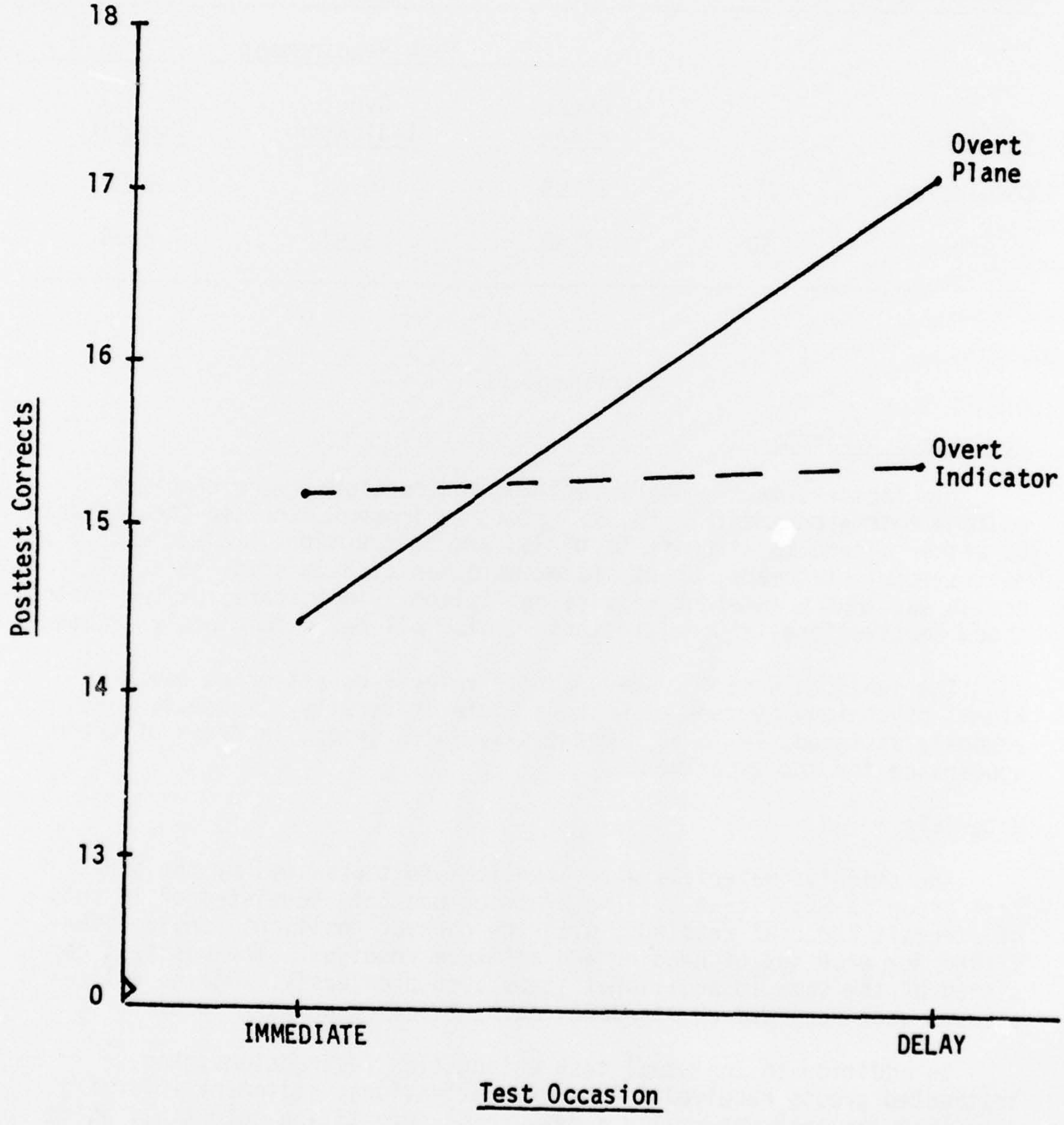

Figure 1. Interaction between task requirement and test occasion ($p < .10$): Experiment II.

Table 2

Means and Standard Deviations for Training

Completion Time: Experiment II

		Task Requirement		
Variable		Overt Plane	Overt Indicator	Control
Completion Time in Minutes	M	21.99	10.80	9.28
	SD	4.96	3.54	4.06

Experiment III

Design and Subjects

Two factors, task requirements and instructions, were combined to form four experimental groups. Task requirement directed the subjects to either attend to aircraft or dials, and instruction involved either a motivational statement, or no statement other than to study hard. The design was thus a two-task requirement (plane x indicators) by two instructions (motivational x none) factorial, with all cells completely crossed.

The subjects were 40 undergraduate volunteers attending educational psychology courses at Arizona State University. Subjects were randomly assigned, 10 to each between-subjects group, in order of their appearance for the experiment.

Materials

The stimulus materials were identical to those used by the control group in Experiment I. The training booklets consisted of 18 sets of aircraft and dial readings, with the correct positional choice identified for each set of heading and attitude readings. The posttest consisted of the same 18 additional items used previously. Again, all responses were recorded on standard, machine scored answer sheets.

In addition to the usual task orientation instructions, the instructed groups received a 100-word motivational statement informing them that the task was really a measure of competition potential, which required a great deal of spacial ability. The subjects were also told that their grades on the test and their relative standing would be posted in order that they might see how they compared to other students performing the task. Subjects in the non-instructed condition were

simply told to study the material closely and try their best to remember the information. The task requirement groups differed in the following manner. The attention-plane group was told to attend closely to the drawings of the planes during training, since much of their test performance would depend on how well they remembered the aircraft positions. Subjects in the attention-indicator condition were given the same instructions regarding the dial readings located at the bottom of each page. The remainder of the written instructions were identical to those in the previous experiments.

Procedure

Subjects were tested in small groups in their regular classrooms. Each experimental session contained learners from all four conditions. As in the previous studies, subjects received their booklets, read preliminary instructions, and then completed the training task without a time limit. The 18-item posttest was administered immediately, again without a time limit.

RESULTS

Once again, the protocols for each subject were scored for both number of correct recalls and amount of time spent on the training materials. Table 3 presents the means and standard deviations for correct performance on the posttest. A 2 (task requirement) by 2 (instructions) analysis of variance on these data yielded a significant main effect for the task requirement factor, $\underline{F}(1,36) = 4.92$, $\underline{p} < .05$. Table 5 gives the means and standard deviations for the completion time data. An analysis of variance for completion times yielded no significant effects.

Table 3

Means and Standard Deviations for

Posttest Corrects: Experiment III

Instruction		Task Requirement: Attend Plane	Task Requirement: Attend Indicator
Directing Statement	M	15.90	14.40
	SD	2.23	2.95
No Statement	M	15.40	12.40
	SD	1.95	4.85

Table 4

Analysis of Variance Source Table for

Posttest Corrects: Experiment III

Source	SS	df	MS	F	p
Task (T)	50.63	1	50.63	4.92	.05
Instruction (I)	15.63	1	15.63	1.52	ns
T x I	5.64	1	5.64	-	ns
Error	370.08	36	10.28		

Table 5

Means and Standard Deviations for

Training Time: Experiment III

Instruction		Attend Plane	Attend Indicator
Directing Statement	M	10.46	11.51
	SD	3.54	4.06
No Statement	M	12.17	9.08
	SD	3.11	1.98

DISCUSSION

The results of Experiment III provide little support for the contention that the effect of image instructions in the previous study is due primarily to the control of attending behavior. Under conditions where there was no overt activity, attending to the aircraft did facilitate test performance; however, there was no interaction between the locus of attention and whether or not the subject received instructions designed to increase motivation. Taking the last two experiments together it seems that sensitivity to heading and attitude information is increased overtly when there is some type of attentional control--at least with the types of materials employed in these studies. However, when there is no overt requirement, the mere fact of being instructed to attend to the aircraft was sufficient to increase posttest performance. Clearly, it seems possible that degree of task involvement can be prescriptively determined, and the types of adjunct procedures varied to fit the expected outcome of the training (e.g., Travers, Van Wagenen, Haygood, & McCormick, 1964).

GENERAL DISCUSSION

The data from these three studies indicate that how a student approaches the task of learning to match his instruments with some representation of aircraft position is not a unitary process. The ability to determine the relative location of an in-flight vehicle from a set of dial indicators is influenced in the naive student by expectation more than by context. If the student is to acquire a facility for spacial representation in ground training, the attentional prompts used should be spacial in nature, especially where some type of overt participation is required for a correct solution. This finding appears to hold especially true if one wishes to assure that the skill components are retained over even a brief interval.

If one hopes to teach instrument sensitivity, and intends to require some type of overt, publicly observable response during training, then the best performance should be some function of the degree to which the learner can be directed to use a spacial processing mechanism during initial encoding. Unfortunately, the present experiments cannot provide a listing of the various devices which might serve the encoding purpose. However, it seems likely that any procedure which forces relational storage of the aircraft position will serve to increase the retention in a significant fashion.

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